Bat Surveys
Giant Forest Village and Vicinity
Sequoia National Park

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EXECUTIVE SUMMARY

The purpose of this study was to assess bat use of buildings in the Giant Forest area, and to evaluate what effect removal of these structures might have on the local bat populations. Since the proposed project also involves extensive restoration work with potential impacts on bats, a subsidiary goal was to obtain initial information on bat diversity, abundance, and habitat use in the area.

Seventeen bat species are known or expected to occur in Sequoia National Park. Ten of these were identified either by netting or acoustic surveys during this study; nine in the Giant Forest area, and one additional species (the western pipistrelle, *Pipistrellus hesperus*) from a lower elevation site (Sycamore Creek) near Ash Mountain. Five are Category 2 Candidates for listing under the Federal Endangered Species Act: the spotted bat, *Euderma maculatum*, the mastiff bat, *Eumops perotis*, the long-eared myotis, *Myotis evotis*, the fringed myotis,*Myotis thysanodes*, and the long-legged myotis, *Myotis volans*. Three of the species are listed as Mammal Species of Special Concern by California department of Fish and Game: *E. maculatum*, *E. perotis*, plus the pallid bat, *Antrozous pallidus*.

A total of 288 buildings located in the Giant Forest area were surveyed for bat use between July 11 and September 15, 1994. Sixty buildings (20.8 %) showed some sign of bat use, and 11 (3.8 %) had bats at the time of survey. In general, the larger buildings, with extensive, partitioned attics, were more likely to have resident bats. The only species found using the buildings were *M.evotis*, and the California myotis, *Myotis californicus*. Six of the larger buildings appeared to have maternity colonies of *M. evotis*. The Giant Forest population of *M. evotis*, a widely distributed but relatively rare species, is the largest we know of in California.

To monitor for bat activity, twenty four guano traps were installed in basal hollows of giant sequoia trees. Although the amount of use varied greatly among the trees, all twenty four were used, primarily as night roosts. A total of five bat species were found to be using the giant sequoias, with the dominant species being *A. pallidus* and the big brown bat, *Eptesicus fuscus*. *E. fuscus* was shown through radiotracking to use exterior bark crevices as day roosts. A colonial day roost, probably of *M.volans*, was found in a basal hollow.

The three most common species in net captures were *A. pallidus*, *E. fuscus*, *M. californicus*. Notable records included the capture of a lactating *E. maculatum*, at Sunset Rock, and multiple acoustic records of *E.perotis*.

Capture rates (bats/m^2 net area*hours) were considerably higher at basal hollows of giant Sequoias than in presumed foraging areas. The highest capture rates in the Giant Forest area were obtained at Sunset Rock. The highest overall capture rates were, however, at Sycamore Creek , an area on average about 10^{o}C warmer than Giant Forest.

This study illustrated the importance of the rock/forest interface to the local bat community. Bat foraging activity was orders of magnitude higher at major rock outcroppings, and at the rock/forest interface than it was within the giant sequoia forest. Although bats were observed flying at dusk near the tree canopies, relatively few were observed near the forest floor. Rock outcrops appeared to serve as "thermal islands," where the heat-retaining granite supported local insect abundance, and thus increased prey densities for bats.

The following actions are recommended: 1) the eight buildings identified as likely maternity roosts for *M. evotis* be monitored (with temperature loggers, guano traps and periodic exit counts) throughout the maternity season to determine duration and patterns of occupancy; 2) appropriate roosting habitat be retained in whatever buildings remain; 3) a radiotracking study of *M. evotis* be conducted to identify natural habitat features this species might use for roosts; 4) the structure at Beetle Rock be evaluated as a possible mitigation site for *M. evotis* displaced from other structures, and should have its night light turned off.

1.0 INTRODUCTION

The purpose of this study was to assess bat use of buildings in the Giant Forest area, and to evaluate what effect removal of these structures might have on the local bat populations. Fifteen of the 17 bat species potentially occurring in the Giant Forest area are known to roost in buildings (Barbour and Davis 1969), where they typically demonstrate high levels of roost fidelity, seasonally reoccupying the same sites over both years and generations. Since many of the Giant Forest buildings have been in existence for up to 50 years, it was important to determine which local bat populations may rely on these structures for roosts, and to evaluate the availability of alternative roosting habitat, particularly within the giant sequoia (*Sequoiadendron giganteum*) groves. Since the proposed project also involves extensive restoration work with potential impacts on bats, a subsidiary goal was to obtain some initial information on bat diversity, abundance, and habitat use in the area.

2.0 METHODS

2.1 Building Surveys

All buildings in the Giant Forest area were visually inspected for the presence of bats or bat sign (guano, staining, or bat carcasses). External inspection were conducted by walking slowly around the exterior looking for guano on the ground or under shingles, searching for possible entry points for bats, and looking under shingles (roofing and siding) for the presence of bats. Internal inspection included investigation of all accessible interior areas, including attic spaces. Occupied motel rooms were not surveyed, but interiors of utility buildings, and more rustic cabins were. For very complex attics which offered numerous cryptic roosting sites, exit surveys were conducted by positioning observers below possible exit points at dusk. An attempt was made to have enough observers to cover all sides of each building. Those buildings which appeared to have significant bat use were examined periodically throughout the summer.

Bats were captured, when possible, in hand nets to determine species, age, sex and reproductive condition. Such captures were generally not conducted until late in the season (September) to minimize disturbance to maternity roosts. Guano was classed as "old" (faded in color and/or covered with a layer of dust) or "new" (darker in color, and dust free). Guano accumulation was assigned to one of three semi-quantitative categories: 1 = only trace amounts (limited to a few pellets); 2 = moderate amounts (either a few separate patches or a thin, disjunct scattering; 3 = large accumulations (a complete covering of a surface in numerous patches, or a consistent scatter throughout).

2.2 Monitoring Bat Use of Giant Sequoia Trees

Using a tree distribution data base and maps provided by Sequoia National Park, we selected 24 trees with basal hollows within the study area to monitor for bat occupation. Guano deposition on suspended debris traps, installed inside the hollows, provided a relative measure of bat use. Traps were installed in 2 trees adjacent to buildings, 8 trees near tourist activity (the Hazelwood Nature Trail, and the vicinity of Round Meadow), and 14 trees well removed from tourist activity (Alta Trail and Crescent Meadow Road). Fourteen traps were installed on June 27 and 28, and an additional 10 traps on July 24. Guano was collected 6 times throughout the season (July 10, 24, August 14, 29, September 11, October 7).

2.3. Bat Capture

Bats were captured inside buildings using hand nets, and in foraging areas and at tree roost entrances using mist nets (Avinet 18' x 6', 42' x 10' and 60' x 10', 1-1/2" mesh, 50 denier nylon nets) suspended on sectional poles. Mist netting was conducted in foraging areas in the Giant Forest Village area on June 27, July 12 & 27, August 29, September 11, 13 &14, and in the Ash Mountain area (Sycamore Creek) on July 13. Netting was conducted at possible tree roosts on September 11, 12, & 14, and October 6 & 7.

2.4. Temperature Monitoring

Stowaway temperature loggers (Onset Computer Corp., Pocasset, MA) were placed in the attic of the cafeteria at Giant Forest Village, and inside the basal hollow of one giant sequoia tree (NE6, G2) to obtain a record of roost temperature variation. Temperatures were monitored from August 20 - October 4.

2.5. Acoustic Monitoring

Levels of bat activity were monitored with bat detectors (Petersson D-100 or D-980). When using the D-100 the number and time of bat passes was manually recorded on a data sheet. For the D-980, bat calls and commentary were recorded on a digital audio tape recorder.

3.0 RESULTS AND DISCUSSION

3.1. Building Surveys, Giant Forest Village

3.1.1. General Patterns of Bat Use

A total of 288 buildings located in the Giant Forest area (Firwood, Giant Forest Lodge, Giant Forest Village, Lower Kaweah, Pinewood, and Upper Kaweah) were surveyed between July 11 and September 15, 1995 for signs of bat habitation. A total of 60 buildings (20.8 %) showed some sign of bat use, and 11 (3.8 %) had bats at the time of survey (see Table 1). In general, the larger buildings, with extensive, partitioned attics, were more likely to have resident bats. We divided the buildings into three categories: cabins/residences; motels; and facility buildings (which ranged from small sheds to the large cafeteria/restaurant structures). Although cabins and residences are the dominant structural type (86.8 % of the buildings), only 14.4 % showed any use by bats, and only 2 (0.8 %) had bats at the time of survey. By contrast, the attics of 7 out of 9 motel units (77.8%) showed use by bats, with three of them (33.3 %) occupied at the time of survey. Facility buildings also received considerable use, with 17 out of 29 (58.6 %) showing some use, and 6 (20.7 %) occupied at the time of survey.

Fig. 1 examines bat use of the buildings based on the amount and the age of guano deposition. Although only 11 of the 60 buildings with guano deposits (18.3 %) were being used by bats at the time of survey, 27 (45 %) had new guano, indicating those buildings were currently or recently used. Twenty-four (40 %) had moderate to large accumulations of guano, suggesting these buildings were of current or past significance to the animals. Thirty-six (60 %) had only trace amounts of guano, indicating that these sites were used by a one or two animals, most likely as night roosts (sites, generally separate from day roosts, used by bats to consume and digest prey) or as transient roosts.

3.1.2. Significance of Building Bat Roosts

Eight of the 9 species confirmed as occurring in the Giant Forest area (see Table 2, Sec. 3.3 below) are known to use building roosts elsewhere in their range. For two, the big brown bat (*Eptesicus fuscus*) and the pallid bat (*Antrozous pallidus*), many of the known roost sites occur in buildings (Barbour and Davis 1969, Hermanson and O'Shea 1983, Kurta and Baker 1990, Orr 1954). Yet, in the Giant Forest area the dominant species using the buildings, and the only species found in the interior of buildings, was the long-eared myotis, *Myotis evotis*. While this species is known to roost in anthropogenic structures, primarily sheds, cabins and deserted buildings (Barbour and Davis 1969, Manning and Jones 1989), it is not generally considered a "house bat.". Only one bat of another species, a California myotis, *Myotis californicus*, was found on the exterior of one building, under a roof shingle.

The 60 buildings which showed some bat use were ranked in order of importance (see Tables 3a & 3b). Six of these, all large buildings (>2,800 sq. ft.), serve as colonial roost sites (as determined by observation of multiple animals or large guano accumulations), most likely for maternity aggregations. In all cases the bats and guano accumulations were confined to the complex attic spaces. Guano deposition in these structures was typically associated with cryptic roosting sites (e.g., below tight crevices, behind boards, inside pipe insulation), typical of maternity locations for crevice dwelling species like *M. evotis*.

Two additional motel attics (Upper Kaweah 201-212 and 239-250) were possible maternity sites. Both had considerable guano accumulations and at some point contained at least one *M. evotis*. *M. evotis* were also observed night roosting in the attic of the 239-250 block.

Small numbers of *M. evotis* and one *M. californicus* were observed at three other sites, which were probably not maternity sites. In Cabin #91 of Giant Forest Lodge, and the trailer at Pinewood, the two individual *M. evotis* that were captured were non-reproductive adult females. The animals observed at the Gift Shop in Giant Forest Village, 5 *M. evotis* and 1 *M. californicus*, were all roosting under shingles on the exterior of the building, and were likely males or non-reproductive females.

A number of other buildings, mostly cabins, had varying amounts of fresh guano (Table 3a). No bats were observed in these buildings. These sites were most likely used as night roosts or transient roosts. It is possible they are used more commonly outside the study period (i.e., earlier in the summer or later in the fall).

Table 3b lists the 32 buildings that had trace to moderate amounts of old guano. It is striking that more than half the 60 buildings used by bats do not appear to be currently used. Without knowing how long guano persists (this varies considerably with microclimate), it is difficult to interpret these data. One possible interpretation is that local bat populations have declined. Another is that there has been a change in the microclimate inside these buildings (e.g., an increase in canopy cover reducing interior temperatures), making them less suitable as roosts. Given that most of these sites have relatively small amounts of guano, indicating use by single animals, the most likely explanation would be that these are transient sites, and not of critical biological importance.

While guano morphology alone is not diagnostic of species, in some cases it provides a fairly reliable indication of which species are using a site. Greater than 90 % of the guano in the buildings appeared to be the same, was associated with known *M. evotis* sites, and was consistent in color, texture, size and shape with guano collected from this species elsewhere (W.E. Rainey

pers. comm., E.D. Pierson pers. obs.). Guano size is roughly correlated with body size (i.e, larger bats produce larger guano pellets); color and texture are correlated with diet (i.e., those species, like *M. evotis*, which eat primarily moths, tend to produce guano that is light brown, and full of moth scales). Trace amounts of smaller, darker guano, attributable to a smaller *Myotis* species was found in only a few buildings. No guano attributable to *A. pallidus* (often associated with scorpion or Jerusalem cricket parts) or *E. fuscus* (large pellets with beetle parts) was found in any building.

3.1.3. Roosting Ecology of *Myotis evotis*

Table 4 documents the dates bats were observed in building roost sites in Giant Forest. Those buildings identified as important based on an initial survey were surveyed more than once. The determination that six buildings likely housed maternity sites was based on the observation of adult/young aggregations, the capture of juvenile animals, and/or the amount of guano present. The group of six *M. evotis* observed (but not captured) in the attic of the Administration Building of Giant Forest Lodge on August 15 was almost certainly a small maternity cluster, since half the animals appeared to be juveniles (i.e., they were smaller and darker than the adults). Although maternity groups were not observed in either the Restaurant or Dispensary of Giant Forest Lodge, the amount and distribution of the guano suggest these buildings are used by multiple animals at some time of year. The presence of a juvenile in the dispensary on September 14 is suggestive. Groups of 6-15 were observed during the maternity season in the attic of the cafeteria of Giant Forest Village.The group of six observed in the attic of the Market is also suggestive of a maternity cluster. In the 225-238 block of the Upper Kaweah Motel, a small animal, identified as a juvenile when handled, was roosting with an adult, most likely its mother. The numbers of bats observed in these buildings is almost certainly an underestimate, since all attics offered numerous cryptic roosting opportunities, some of which were inaccessible to investigators.

The small colony sizes and cryptic roosting habits observed in Giant Forest are consistent with what is known of the roosting ecology of *M. evotis* elsewhere in its range (Barbour and Davis 1969, Manning and Jones 1989). Because the animals roosted very quietly in concealed localities (e.g., inside pipe insulation, behind roofing slats), it is was never possible to be certain we had located all the bats in a building. In fact, it was evident from conducting an emergence count at the cafeteria in Giant Forest Village that we had not. Interior inspection on September 15 had revealed no animals, whereas 14 were counted on emergence at dusk. Unlike some colonial species (e.g., the little brown bat, *Myotis lucifugus*), which would be likely to form a single large aggregation in one building, this species formed small groups distributed over several buildings. While we do not know what the relationship is among these groups (e.g., whether animals shift among groups), nor how loyal any one group is to a particular site, it is obvious that 6-8 buildings in the Giant Forest area are providing significant roosting habitat for this species.

Recent research into the roosting ecology of *M. evotis* suggests that even though this species can be found at relatively high elevations (e.g., up to 2,830 m in Wyoming) and latitudes (up to central British Columbia in Canada) (Manning and Jones 1989), it seeks exceedingly warm roost temperatures (Vonhof 1995). A comparison of the temperatures in the attic of Giant Forest Village Cafeteria and inside a giant sequoia fire scar (Fig. 2) show that the attic maintained consistently higher temperatures than the tree hollow. On September 14 (ca. 14:00), when ambient temperature was about 27°C, the temperature at the *M. evotis* roosting site in Motel unit 225-238 was 41°C.

A mummified marten (*Martes americana*) was found in the attic of the Giant Forest Lodge Restaurant, and carnivore scat was located below the bat roosting areas in this building and the

Village Cafeteria. A cursory dissection of three scat samples from the Cafeteria revealed a mixture of insect parts (mostly beetles) and mammal fur, some of it light brown in color, and thus possibly attributable to *M. evotis*. The scat, mostly ca. 1.5-2" in length and 0.25-0.5" thick, appeared to be too small for marten (Murie 1974). Another possible predator would be the ringtail, *Bassariscus astutus*, known to feed on bats (Ingles 1965). The available evidence suggests that small carnivores may be preying on bats in the attics. The importance of this is not known.

3.2. Bat Use of the Giant Sequoias

Twenty four guano traps were installed in giant sequoia trees with basal hollows to monitor bat activity. Although the amount of bat use, as indexed by the weight of guano and culled insects parts deposited per day, varied greatly among the trees (Table 5, Fig. 3), all twenty four trees were used. Netting and observation of trees with night vision equipment suggested that the majority of sampled hollows were being used as night roosts. The dominant species using the trees appeared to be *A. pallidus* and *E. fuscus*. Culled insect parts (scorpions and Jerusalem crickets), identifiable as the prey of *A. pallidus*, was found in 11 trees. A substantial night roost for this species is located in tree #L68 (NW6) in the Hazelwood area. Although both these species are commonly found in buildings, recent work has shown that both roost extensively in trees (Barclay and Brigham 1996, Brigham 1991, S. Cross pers. comm., Rainey and Pierson 1996), including the basal hollows of coast redwood (Orr 1954, Rainey *et. al.* 1992)

Of the nine species identified as occurring in Giant Forest, five were found to be using the giant sequoias as night roosts (Table 6a), with *E. fuscus* and possibly *Myotis volans* also identified as using them for day roosts. A radio transmitter attached to one male *E. fuscus* captured at a tree night roost, revealed day roosts in exterior small bark cavities, ca. 4 m above the ground, in two giant sequoia trees, both within 1 km. of the initial capture site (NW6, B74), near Round Meadow.

Additionally, one tree (NW6, M4) in the Hazelwood area appeared to contain a day roost inside the basal hollow. On June 27 bats were heard during the day at this tree, and a small group (< 12) emerged at dusk. They appeared to be a medium to large size *Myotis*. Since a *M.volans* was captured within 5 m of this tree later in the evening, at a time when there was bat activity in and out of the tree, it is likely an aggregation of this species was using the tree. On all subsequent surveys, however, there did not appear to be bats day roosting in this tree.

Amount of bat use of tree hollows was not correlated with proximity to buildings nor amount of tourist activity in the area (Table 5). Although neither tree close to buildings (level of tourist activity = 1) received much bat use, there was no apparent difference between these trees and a number of the others. Use was also only weakly correlated with DBH.

3.3. Bat Diversity and Habitat Associations in the Giant Forest Area

Mist-netting was conducted in three areas in Giant Forest, and at Sycamore Creek in the Ash Mountain area (See Table 6a,b,c). In the Giant Forest area, nets were set in presumed foraging habitat or flyways within the giant sequoia forest (e.g., across streams and trails, and between trees); at the rock/forest interface at Sunset Rock; and across basal hollows of trees known to receive bat use. The three most common species in net captures were the pallid bat, *A. pallidus*, the big brown bat, *E. fuscus*, and the California myotis, *M. californicus*. Notably absent in the captures was *M. lucifugus*, a species reasonably expected to be common at higher elevations (Grinnell and Storer 1924).

While the highest capture rates for bats are generally obtained by setting nets over water or along flyways (Kunz and Kurta 1988), in this habitat these were the least productive settings (Table 6b). Capture rates (bats/m^2 net area*hours) were considerably higher at basal hollows of giant sequoias, known on the basis of guano deposition to have bat use (Table 6a). The highest capture rates in the Giant Forest area were obtained at Sunset Rock (Table 6b). The greatest number of bats per unit effort were captured, however, at Sycamore Creek , an area 1,330 m lower in elevation, and on average about 10°C warmer than Giant Forest (Fig. 4).

Seventeen bat species are known or expected to occur in Sequoia National Park (Table 2). Ten of these were identified either by netting or acoustic surveys during this study; nine in the Giant Forest area, and one additional species (the western pipistrelle,*Pipistrellus hesperus*) from a lower elevation site (Sycamore Creek) near Ash Mountain. The Giant Forest area had the largest concentration of *M. evotis* we have encountered in California. This species, which appears to be rare in much of the state, was relatively abundant in this habitat. Although the spotted bat, *Euderma maculatum*, was known from Sequoia and Kings Canyon National Parks (Cedar Grove [D. Graber, pers. comm.], Wilsonia [Specimen #16721, California Academy of Sciences], Twin Lakes near Silliman Pass, Kings River below Bench Lake, and Deadman Canyon [Pierson and Rainey 1995b]), the capture of a lactating female (Fig. 5) at Sunset Rock provided a new locality record for this species within the park. The mastiff bat, *Eumops perotis*, had been identified as occurring near Ash Mountain (Pierson and Rainey 1995b), but was recorded for the first time from the Giant Forest area. The Mexican free-tailed bat, *Tadarida brasiliensis*, although never caught in nets, appeared to be relatively abundant in the Moro Rock area, based on acoustic survey.

3.3.1. Bat Activity at Rock Outcrops and within the Giant Sequoia Groves

Acoustic monitoring of bat activity was generally conducted in parallel with the netting efforts, as well as on additional nights (June 26-27, July 12-13, 24- 27, August 14, 16, September 11-15, October 6- 7). Bat activity was orders of magnitude higher near major rock outcroppings, at the rock/forest interface. Except for a brief burst of activity one evening (26 June) at Round Meadow, it was unusual to detect more than 2-3 bat passes per hour on the forest floor within giant sequoia habitat. Although we could observe bats at dusk 25-30 m above the forest floor, close to the canopy of the giant sequoia trees, they were inaudible to the bat detectors. The only species that appeared to be foraging regularly near the forest floor was the pallid bat, *A. pallidus*. By contrast, at Sunset Rock (September 13), Beetle Rock (August 14), and especially Moro Rock (July 24, 25, August 16, September 15) bat activity was generally intense and continuous (multiple animals of more than one species) for the first 1-2 hours after dark. From an observation point part way up Moro Rock (September 15), bats could be detected foraging at the rock/forest interface and above the forest canopy. This discrepancy in activity between the rock outcrops and the forest floor is likely driven by local patterns of prey distribution, which in turn is driven by temperature. Many more flying insects were observed in association with the rock outcrops, which retained heat longer, and were generally warmer, than the forest floor.

Although many bat species cannot be identified with certainty based on acoustic surveys alone, the echolocation calls of *E. maculatum*, *E. perotis*, and *T. brasiliensis* are generally distinctive (Pierson and Rainey 1995b, Woodsworth *et. al.* 1981), with those of *E. maculatum* and *E. perotis* being generally audible (i.e., below 15 kHz). Although *E. maculatum* was observed with night vision goggles and captured in a net at Sunset rock, it was identified by acoustic signals at several other localities, including another rock outcrop on Crescent Meadow Road (Table 7). While *E. perotis* was never captured in a net, it was heard relatively frequently, also frequently associated with rock outcrops (Table 7). As in Yosemite National Park, where the two species co-occur (Pierson and Rainey 1995a), *E. perotis* appears to be more common than *E. maculatum*

(although this may partly reflect a greater acoustic detection radius for *E. perotis*). A high concentration of *E. perotis* near Moro Rock suggest that this colonial species, known to roost under exfoliating granite, likely has a roost here.

Netting also indicated bat activity was higher at rock outcrops. More bats were captured per unit effort at Sunset Rock than at other netting stations in the Giant Forest area (Table 6a & b). During a four hour netting session on September 13 at the rock/forest interface at Sunset Rock, 7 bats were captured, 4 of these (representing three species) were ESA Category 2 Federal candidates -- one *E. maculatum*, two *Myotis thysanodes*, and one *M. evotis* (Table 6b). All three species were represented by reproductive females. A fourth Category 2 species, *E. perotis* (mastiff bat) was detected acoustically, and its echolocation calls recorded.

3.3.2. Observations on the Spotted Bat, *E. maculatum* in the Giant Forest Area

The spotted bat, *E. maculatum*, was detected at four localities in the study area, Sunset Rock, a rock outcrop on Crescent Meadow Road, Round Meadow, and the Hazelwood Nature Trail (Table 7). The only place it was detected foraging was at the two rock outcrops.

The capture of a spotted bat at Sunset Rock is highly significant. Prior to the initiation of statewide surveys on the status of this species funded by California Department of Fish and Game in 1993 (Pierson and Rainey 1995b), there were only thirteen known records (published localities or museum specimens) for this species in California. With the exception of the record for Cedar Grove (D. Graber pers. comm.), all these were isolated records of dead or moribund animals. No viable populations were known. In the course of several studies conducted for Calif. Dept. of Fish and Game and Yosemite National Park, populations were identified in the Tuolumne and Merced River drainages, and in the vicinity of Castle Crags State Park (Pierson and Rainey 1993, 1995a, 1995b; Rainey and Pierson 1994). The record for Sunset Rock represents only the third locality at which live animals have been captured in California.

This individual was first detected acoustically, foraging along the forest edge, at the interface between the granite and the forest. Its foraging behavior was monitored with night vision equipment for about 20 minutes prior to capture. Its behavior was consistent with observations at other localities indicating that this species is sometimes territorial, and may forage for long periods in the same area (Leonard and Fenton 1983; Pierson and Rainey 1993, 1994, 1995a, 1995b, Pierson and Rainey unpubl. obs.; Wai-Ping and Fenton 1989; Woodsworth et al. 1981). The spotted bat appears to be more restricted in its foraging habitat requirements than most other species, and is found most frequently foraging in mesic vegetated edge situations (e.g., in meadows, at the rock/forest interface, or riparian areas in desert settings).

3.3.3. Meadows

The only areas within the giant sequoia grove where relatively large numbers of bats were detected foraging within 10 m of the ground was at rock outcrops and at Round Meadow. Work in Yosemite National Park has shown that ungrazed meadows provide important foraging habitat for both *E. maculatum* and *E. perotis*. A number of other bat species, including *M. evotis*, are also known to use meadows, forest clearings, and/or the forest edge as foraging habitat (Manning and Jones 1989).

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1. Bat Use of Buildings and Expected Impacts of Demolition

This study documented that bat use of the small cabins is minimal, and not anywhere of critical importance. Thus these buildings could be demolished at anytime without additional concern. Demolition of those motel units and facility buildings demonstrated to be important bat roosts will require more planning.

The Giant Forest area has the largest concentration of *M. evotis* maternity sites we know of in California. *M. evotis* is a Category 2 (C2) candidate for listing under the Federal Endangered Species Act, and is considered a Mammal Species of Special Concern (MSSC) by California Department of Fish and Game. Although this species is widely distributed and occurs fairly frequently as one of the rarer taxa in netting surveys, we know of only 4 or 5 current maternity sites anywhere in California. In this context, the building roosts at Giant Forest are significant, and their removal, without proper planning, could have a serious impact on the local population.

The importance of these building roosts was not immediately evident. Cryptic roosting habits made the animals difficult to detect. Also, some of the more important buildings were not surveyed until late in the season. Thus, to minimize impacts on this species in the Giant Forest area, we recommend that the following additional steps be taken:

1. The eight buildings identified as likely or possible maternity sites should be monitored by exit counts at regular intervals (every 2-4 weeks) throughout the next breeding season to determine extent and duration of use by bats. Temperature loggers and guano traps (plastic tarps placed beneath roosting areas) should be installed in April (prior to the formation of maternity colonies), and run throughout the maternity season (until the colonies disperse in the fall -- likely by mid-October). Temperature loggers would provide information on roost temperature requirements for this species, and the amount of guano deposition on tarps would provide a relative indication of amount of use of specific sites. Once the duration of occupancy is determined, a schedule could be suggested for demolition.

2. Since a significant number of animals will be displaced by the removal of these buildings, two steps should be taken to mitigate for this loss:

   a. Appropriate roosting habitat should be retained in whatever buildings remain, particularly the Giant Forest market building (proposed for conversion to a visitor center/museum), which is currently used as a maternity roost. This means that renovation of this and other buildings should provide access points into the attic space for the bats. Educational materials on the bats of Giant Forest, including a video display, could be developed for tourists at the visitor center. Also, the structure at Beetle Rock, if destined to remain, should be further evaluated as a potential mitigation site.

   b. A radiotracking study should be conducted to learn what natural habitat features this species might use for roosts in this habitat. This could be done by placing small (0.4 g) radio transmitters on animals captured in natural settings (e.g., at Sunset Rock) and in the building roosts. Such a study would likely provide information on alternate roost sites, and allow some determination of how loyal animals are to the building roosts.

4.2. Natural Habitat for Bats in the Giant Forest Area

4.2.1. Giant Sequoia Trees

The data gathered in this study suggest that the basal hollows of the giant sequoia trees are used primarily as night roosts, particularly for *A. pallidus* and *E. fuscus*. While a study of fire-scarred redwoods at a central California coastal locality demonstrated significant use of basal hollows by bats for maternity sites and night roosts (Rainey *et al.* 1992), based on this sample, basal cavities of giant sequoias do not appear to be used as maternity sites. It is likely that in the higher elevation giant sequoia forest the relatively cool temperatures of the basal hollows make them inappropriate as maternity sites. As suggested by our pilot radiotracking effort with a single *E. fuscus*, bats are likely using warmer exterior bark cavities and canopy level cracks as day roosts. This would be consistent with the findings of a number of recent studies on tree dwelling bats, which have generally found maternity sites to be located >10 m above ground level, in localities with relatively high sun exposure (Barclay and Brigham in press; see also Abstracts of Bats and Forests Symposium, published in Bat Research News 36(4):24-32 [1995]).

The relevant question for this inquiry is what natural habitat is available to the *M. evotis* populations which will be displaced by the removal of building roosts. Although our netting efforts suggests *M. evotis* may use the basal hollows as night roosts (Table 6a), the extent to which they may use the giant sequoias as day roosts is unknown. The species has also been found in tree hollows and under bark (Manning and Jones 1989). Recent studies in Canada have found males roosting in tree stumps (Vonhof 1995). Another study in Arizona found small maternity roosts in ground level boulder crevices (Morrell *et al.* 1996). In Oregon, maternity clusters have been found under rock shelters in boulder jumbles (M. Perkins pers. comm.). Given this information it seems highly likely that bark crevices of giant sequoia trees are used as roost sites. The preferred location of such roosts (e.g., their height above the ground) has important management implications (particularly for prescribed burns), and could only be determined by the radiotracking effort proposed above.

4.2.2. Rock Outcrops

Our data suggest that the rock/forest interface provides critical foraging habitat for the bat community. Areas of heat-retaining granite apparently serve as "thermal islands," supporting localized insect abundance, and thus providing enhanced prey densities for bats. Rock features are also used extensively by many bat species as roosting sites. The distribution of both *E. maculatum* and *E. perotis*, for example, appears limited geomorphically to areas with substantial rock features (Pierson and Rainey 1994).

Tourist development of rock outcrop areas (e.g., a parking lot at Sunset Rock) would likely have a significant impact on foraging by the bat community, causing local habitat destruction, and providing a continuing source of disturbance (headlights, flashlights, increased human densities), and contamination (oil, gas, exhaust emissions). Food debris, typically associated with human activity sites, would likely attract and maintain locally elevated densities of small scavengers and carnivores.

The data are limited, and the biology of the organisms poorly known, but it is a reasonable presumption that development of rock outcrop areas would differentially affect *E. maculatum*. Not only does this species appear to have relatively restrictive foraging requirements, and show loyalty to particular foraging sites, it is also highly sensitive to disturbance, and intolerant of artificial light. Turning on a headlamp for a few seconds at Sunset Rock, drove the animal away for several

minutes. A radiotracked individual in Yosemite returned to its roost site for half an hour when lights were turned on near its foraging area. While some behavioral accommodation might be expected (i.e., spotted bats have been heard passing over -- although not foraging in -- roads and parking areas in Yosemite National Park), local degradation of foraging habitat would likely have a negative effect on this species, and other members of the bat community. The night light on the building at Beetle Rock should be turned off.

4.2.3. Meadows

Given that meadows were one of the few areas within the giant sequoia grove where bats were detected foraging, any meadow restoration is likely to enhance the foraging habitat for a large segment of the bat community.

5.0 ACKNOWLEDGMENTS

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Table 1. Bat use of buildings in Giant Forest Village, July-August 1995.

	Total No. Surveyed	Total No. w/ Bat Sign	% w/ Bat Sign	Total No. w/ Bats	% w/ Bats
CABINS/RESIDENCES					
Firwood	1	0	0.00	0	0.00
Giant Forest Lodge	88	21	23.86	1	1.14
Giant Forst Village	1	1	100.00	0	0.00
Lower Kaweah	81	12	14.81	0	0.00
Pinewood	78	1	1.28	1	1.28
Upper Kaweah	1	1	100.00	0	0.00
Totals	**250**	**36**	**14.40**	**2**	**0.80**
MOTELS					
Upper Kaweah	9	7	77.78	3	33.33
Totals	**9**	**7**	**77.78**	**3**	**33.33**
FACILITY BUILDINGS					
Castle Rock	3	3	100.00	0	0.00
Giant Forest Lodge	8	6	75.00	3	37.50
Giant Forest Village	7	5	71.43	3	42.86
Lower Kaweah	7	0	0.00	0	0.00
Pinewood	1	1	100.00	0	0.00
Upper Kaweah	3	2	66.67	0	0.00
Totals	**29**	**17**	**58.62**	**6**	**20.69**
Overall Totals	**288**	**60**	**20.83**	**11**	**3.82**

Table 2. Bat species known or considered likely to occur in Sequoia National Park, noting those species identified in 1995 by netting or acoustic records. AM = Ash Mountain, GF = Giant Forest.

SPECIES		NETTING RECORD	ACOUSTIC RECORD
Family VESPERTILIONIDAE (mouse-eared bats)			
Antrozous pallidus	Pallid bat[1]	AM, GF	
Eptesicus fuscus	Big brown bat	AM, GF	
Euderma maculatum	Spotted bat[1,2]	GF	GF
Lasionycteris noctivagans	Silver haired bat		
Lasiurus blossevillii (= *borealis*)	Red bat		
Lasiurus cinereus	Hoary bat		
Myotis californicus	California myotis	GF	
Myotis ciliolabrum (= *leibii*)	Small-footed myotis [2]		
Myotis evotis	Long-eared myotis [2]	GF	
Myotis lucifugus	Little brown myotis		
Myotis thysanodes	Fringed myotis[2]	GF	
Myotis volans	Long-legged myotis[2]	GF	
Myotis yumanensis	Yuma myotis[2]		
Pipistrellus hesperus	Western pipistrelle	AM	
Corynorhinus (=*Plecotus*)*townsendii*	Townsend's big-eared bat[1,2]		
Family MOLOSSIDAE (free-tailed bats)			
Eumops perotis	Western mastiff bat[1,2]		AM, GF
Tadarida brasiliensis	Mexican free-tailed bat		GF

[1] California Department of Fish and Game, Mammal of Special Concern or Sensitive Species
[2] Candidate (Category 2) for listing under U.S. Endangered Species Act

Table 3a. Buildings currently used by bats, with categories listed in order of significance.

CATEGORY	LOCATION	BLDG. #	TYPE	SPECIES
LIKELY MATERNITY/COLONIAL SITE				
	Giant Forest Lodge		Administration	*M. evotis*
	Upper Kaweah	225-238	Motel	*M. evotis*
	Giant Forest Village		Cafeteria	*M. evotis*
	Giant Forest Village		Market	*M. evotis*
	Giant Forest Lodge		Restaurant	*M. evotis*
	Giant Forest Lodge		Dispensary	*M. evotis*
POSSIBLE MATERNITY/COLONIAL SITE (NEW GUANO, ACCUMULATION LEVEL = 3)				
	Upper Kaweah	201-212	Motel	*M. evotis*
	Upper Kaweah	239-250	Motel	*M. evotis*
BATS PRESENT, NOT LIKELY A MATERNITY SITE (NEW GUANO, ACCUMULATION LEVEL = 1)				
	Giant Forest Lodge	91	cabin	*M. evotis*
	Pinewood		Trailer w/ roof	*M. evotis*
	Giant Forest Village		Gift Shop[1]	*M. evotis*
				M. californicus
NEW GUANO, ACCUMULATION LEVEL = 3				
	Lower Kaweah	413	rustic cabin	
	Giant Forest Lodge	14	cabin	
	Giant Forest Lodge	38	cabin	
	Giant Forest Lodge	39	cabin	
	Giant Forest Lodge	49	cabin	
	Giant Forest Lodge	81/82	cabin	
NEW GUANO, ACCUMULATION LEVEL = 2				
	Giant Forest Lodge	27	cabin	
	Giant Forest Lodge	58	cabin	
	Giant Forest Lodge		Shower	
	Upper Kaweah		Beatle Rock Ctr	
NEW GUANO, ACCUMULATION LEVEL = 1				
	Lower Kaweah	305	rustic cabin	
	Lower Kaweah	311	rustic cabin	
	Lower Kaweah	323	rustic cabin	
	Castle Rock		Shop-784 sq. ft.	
	Castle Rock		Shop-482 sq. ft.	
	Upper Kaweah	213-224	Motel	
	Upper Kaweah		Residence	

[1] All bats were on exterior of buidling, under roof shingles.

Table 3b. Buildings with indication of past use by bats, with categories listed in order of significance

CATEGORY	LOCATION	BLDG. #	TYPE
OLD GUANO, ACCUMULATION LEVEL = 2			
	Lower Kaweah	312	rustic cabin
	Giant Forest Lodge	100	cabin
	Giant Forest Lodge		Maintainance
	Upper Kaweah		Warehouse
OLD GUANO, ACCUMULATION LEVEL = 1			
	Lower Kaweah	304	rustic cabin
	Lower Kaweah	310	rustic cabin
	Lower Kaweah	320	rustic cabin
	Lower Kaweah	325	rustic cabin
	Lower Kaweah	329	rustic cabin
	Lower Kaweah	408/409	rustic cabin
	Lower Kaweah	541	rustic cabin
	Castle Rock		Shop-329 sq. ft.
	Giant Forest Lodge	58	cabin
	Giant Forest Lodge	9	cabin
	Giant Forest Lodge	16	cabin
	Giant Forest Lodge	18	cabin
	Giant Forest Lodge	20	cabin
	Giant Forest Lodge	34	cabin
	Giant Forest Lodge	35	cabin
	Giant Forest Lodge	47	cabin
	Giant Forest Lodge	48	cabin
	Giant Forest Lodge	88	cabin
	Giant Forest Lodge	92	cabin
	Giant Forest Lodge		Residence
	Giant Forest Lodge		Linen
	Giant Forest Village		Residence
	Giant Forest Village		Maint - 699 sq. ft.
	Giant Forest Village		Maint. - 544 sq. ft.
	Pinewood		Shed
	Upper Kaweah	111-118	Motel
	Upper Kaweah	119-129	Motel
	Upper Kaweah	130-133	Motel

Table 4. Bat occupancy records for 11 buildings with resident bats. Under Age/Sex column, A = adult, J = juvenile, F = female, M = male. + = flying bats make count uncertain. Nursery sites in bold

Building	Date	Bat Species	# Bats	Age/Sex
GIANT FOREST LODGE				
Cabin 91	8/19/95	*M. evotis*	1	AF
Administration	**8/15/95**	***M. evotis***	**6**	
	9/14/95		**0**	
	10/6/95		**0**	
Restaurant	**8/28/95**	***M. evotis***	**1**	**AM**
	9/14/95	***M. evotis***	**1**	
	10/6/95		**0**	
Dispensary	**8/19/95**	***M. evotis***	**1**	
	9/14/95	***M. evotis***	**1**	**JM**
GIANT FOREST VILLAGE				
Cafeteria	**7/11/95**	***M. evotis***	**6+**	
	7/25/95	***M. evotis***	**1+**	
	8/18/95	***M. evotis***	**2+**	
	9/15/95	***M. evotis***	**14**	
	10/6/95		**0**	
Market	**7/11/95**	***M. evotis***	**6**	
	8/17/95	***M. evotis***	**1**	
	9/14/95		**0**	
	10/6/95	***M. evotis***	**1**	
Gift Shop	7/11/95	*M. californicus*	1	
		M. evotis	3	
	7/25/95	*M. evotis*	1	
	10/6/95	*M. evotis*	1	
PINEWOOD				
Trailer w/ roof	8/21/95	*M. evotis*	1	AF
UPPER KAWEAH				
Motel 201-212	7/26/95	*M. evotis*	1	
Motel 225-238	**7/26/95**	***M. evotis***	**1**	
	9/15/95	*M. evotis*	3	1JM, 2A
Motel 239-250	7/26/95	*M. evotis*	1	
	8/18/95	*M. evotis*	5	
	9/13/95		0	

Table 5. Location, size, amount of bat use, and proximity to tourists for 24 giant sequoia trees with guano traps installed inside basal hollows. Tourist activity in the vicinity is rated 1 = high, 2 = moderate, 3 = little or none.

Date Installed	Trap #	Sec	Tree#	DBH (ft.)	Guano mg/day	Tourist Activity	General Locality
6/28/95	1	NE 6	H5	11	20.18	3	Alta Trail
6/28/95	2	NE 6	B22	11	4.35	3	Alta Trail
6/28/95	3	NE 6	B33	8	21.62	3	Alta Trail
6/28/95	4	NE 6	G11	13	5.40	3	Alta Trail
6/29/95	5	SE 1	D5	7	78.82	3	Crescent Mdw.Rd.
6/29/95	6	SE 1	D26	9	44.60	3	Crescent Mdw.Rd.
6/29/95	7	SW 6	O19	14	3.91	3	Crescent Mdw.Rd.
6/29/95	8	SW 6	J9	12	2.41	3	Crescent Mdw.Rd.
6/29/95	9	SW 6	H30,H31	9-Aug	9.90	3	Crescent Mdw.Rd.
6/29/95	10	NW 6	P1	13	5.90	1	Giant Forest Village
6/29/95	11	NW 6	K39	11	2.76	1	Giant Forest Village
6/29/95	12	NW 6	M4	16	4.00	2	Hazelwood
6/29/95	13	NW 6	L68	17	308.47	2	Hazelwood
6/29/95	14	NW 6	J24,25	20,16	6.29	2	Round Mdw.
7/24/95	15	NW 6	B73	13	34.36	2	Round Mdw.
7/24/95	16	NW 6	B74	13	7.80	2	Round Mdw.
7/24/95	17	NW 6	G2	12	93.77	2	Round Mdw.
7/24/95	18	NW6	B40	9	56.62	2	Round Mdw.
7/24/95	19	NW6	C64	17	3.84	2	Round Mdw.
7/24/95	20	SE 6	M19,20	12,15	0.32	3	Crescent Mdw.Rd.
7/24/95	21	SE 6	L 30	14	13.89	3	Crescent Mdw.Rd.
7/24/95	22	SE 6	L28	14	30.70	3	Crescent Mdw.Rd.
7/24/95	23	SW6	D18	13	12.02	3	Crescent Mdw.Rd.
7/24/95	24	SW6	F7	13	19.10	3	Crescent Mdw.Rd.

Tourist 1 = near buildings; 2 = tourist activity nearby; 3 = little or no tourist activity

Table 6a. Sex, age, reproductive condition, and capture rate for bats mist-netted at basal hollows of of giant sequoia trees, September-October 1995.

Locality	Sex	Age/Repro. Cond.	*A. pallidus*	*E. fuscus*	*E. maculatum*	*M. californicus*	*M. evotis*	*M. thysanodes*	*M. volans*	*P. hesperus*	Totals	Effort (M^2 Net Area*Hrs)	Bats/Unit Effort
BASAL HOLLOWS, GIANT SEQUOIA TREES													
Trees (B73, B74, G2), Round Meadow (Sept. 11)													
	Male	Adult	3	1							4		
			3	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**135.00**	**0.030**
Trees (L28, L30), Crescent Meadow Rd. (Sept. 12)													
	Female	Nulliparous					1				1		
	Male	Adult				1		1			2		
			0	**0**	**0**	**1**	**1**	**1**	**0**	**0**	**3**	**270.00**	**0.011**
Tree (M4), Hazelwood Nature Trail (Sept. 14)													
			0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**210.69**	**0.000**
Trees (D5, D26), Crescent Meadow Rd. (Oct. 6)													
	Female	Post-lactating	1								1		
	Male	Adult	1								1		
			2	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**140.46**	**0.142**
Trees (B40, G2), Round Meadow (Oct. 7)													
			0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**140.46**	**0.000**
Totals			**5**	**1**	**0**	**1**	**1**	**1**	**0**	**0**	**9**	**896.61**	**0.010**

Table 6b. A comparison of bat captures in giant sequoia habitat trees and at the rock forest interface in the Giant Forest area, Sequoia National Park, June- September 1995.

Locality	Sex	Age/Repro. Cond.	*A. pallidus*	*E. fuscus*	*E. maculatum*	*M. californicus*	*M. evotis*	*M. thysanodes*	*M. volans*	*P. hesperus*	Totals	Effort (M^2 Net Area*Hrs)	Bats/Unit Effort
GIANT SEQUOIA HABITAT													
Hazelwood Nature Trail (June 27)													
	Male	Adult				1			1		2		
			0	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**2**	**536.50**	**0.004**
Little Deer Creek (July 12)													
			0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**401.33**	**0.000**
General's Highway, Sec 31 I (July 27)													
	Female	Nulliparous		1									
	Male	Adult		2									
			0	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**273.13**	**0.011**
Little Deer Creek (August 29)													
			0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**156.07**	**0.000**
Near Burnt Twins, Crescent Meadow Rd (Aug. 30)													
	Male	Adult	2								2		
			2	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**292.64**	**0.007**
Adjacent to Round Meadow (Sept. 11)													
			0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**73.13**	**0.000**
Hazelwood Nature Trail (Sept. 14)													
			0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**351.16**	**0.000**
Totals			**2**	**3**	**0**	**1**	**0**	**0**	**1**	**0**	**7**	**2083.96**	**0.003**
ROCK/FOREST INTERFACE													
Sunset Rock (Sept. 13)													
	Female	Lactating					1				1		
		Post-lactating			1			1			2		
	Male	Adult	1			2		1			4		
Totals			**1**	**0**	**1**	**2**	**1**	**2**	**0**	**0**	**7**	**422.37**	**0.017**
Overall Totals			**3**	**3**	**1**	**3**	**1**	**2**	**1**	**0**	**14**	**2506.33**	**0.006**

Table 6c. Sex, age, reproductive condition, and capture rate for bats mist-netted in Ash Mountain area, Sequoia National Park, July 1995.

Locality	Sex	Age/Repro. Cond.	*A. pallidus*	*E. fuscus*	*E. maculatum*	*M. californicus*	*M. evotis*	*M. thysanodes*	*M. volans*	*P. hesperus*	Total	Effort (M^2 Net Area*Hrs)	Bats/Unit Effort
ASH MOUNTAIN AREA													
Sycamore Creek (July 13)													
	Female	Pregnant								1	1		
		Lactating								1	1		
	Male	Adult	6	23							29		
Totals			**6**	**23**	**0**	**0**	**0**	**0**	**0**	**2**	**31**	**691.18**	**0.045**

Table 7. Acoustic detection of *E. maculatum* and *E. perotis* in Sequoia National Park and vicinity, June-October 1995.

LOCALITY	DATE	NUMBER OF EVENTS	
		E. PEROTIS	*E. MACULATUM*
GIANT FOREST			
Beetle Rock	8/14/95	Multiple foraging	
Crescent Meadow Rd.	10/6/95	1	
Crescent Mdw. Rd., near Tree L28	9/12/95	3, 1 foraging	
Crescent Mdw. Rd., rock outcrop	10/6/95		1 foraging
Giant Forest Lodge	7/26/95	1	
Giant Forest Village	7/26/95	1	
Hazelwood Nature Trail	6/27/95	1	
	9/14/95		1
Lower Kaweah	6/27/95	Multiple	
Moro Rock	8/16/95	Multiple	
	9/15/95	Multiple foraging	
Pinewood, rock outcrop	7/27/95	Multiple foraging	
Round Meadow	9/11/95	1	1
	10/7/95	1	
Sunset Rock	9/13/95	3	1 (captured)
ASH MOUNTAIN			
Sycamore Creek	7/13/95	Several	
THREE RIVERS			
Best Western Motel	7/14/95	1	

Fig. 1. Bat use of buildings. Guano 1 = trace amounts of guano; Guano 2 = moderate amounts; Guano 3 = large accumulations. Old Guano = faded in color and covered with dust; New Guano = darker in color and dust free.

Bat Use of Buildings

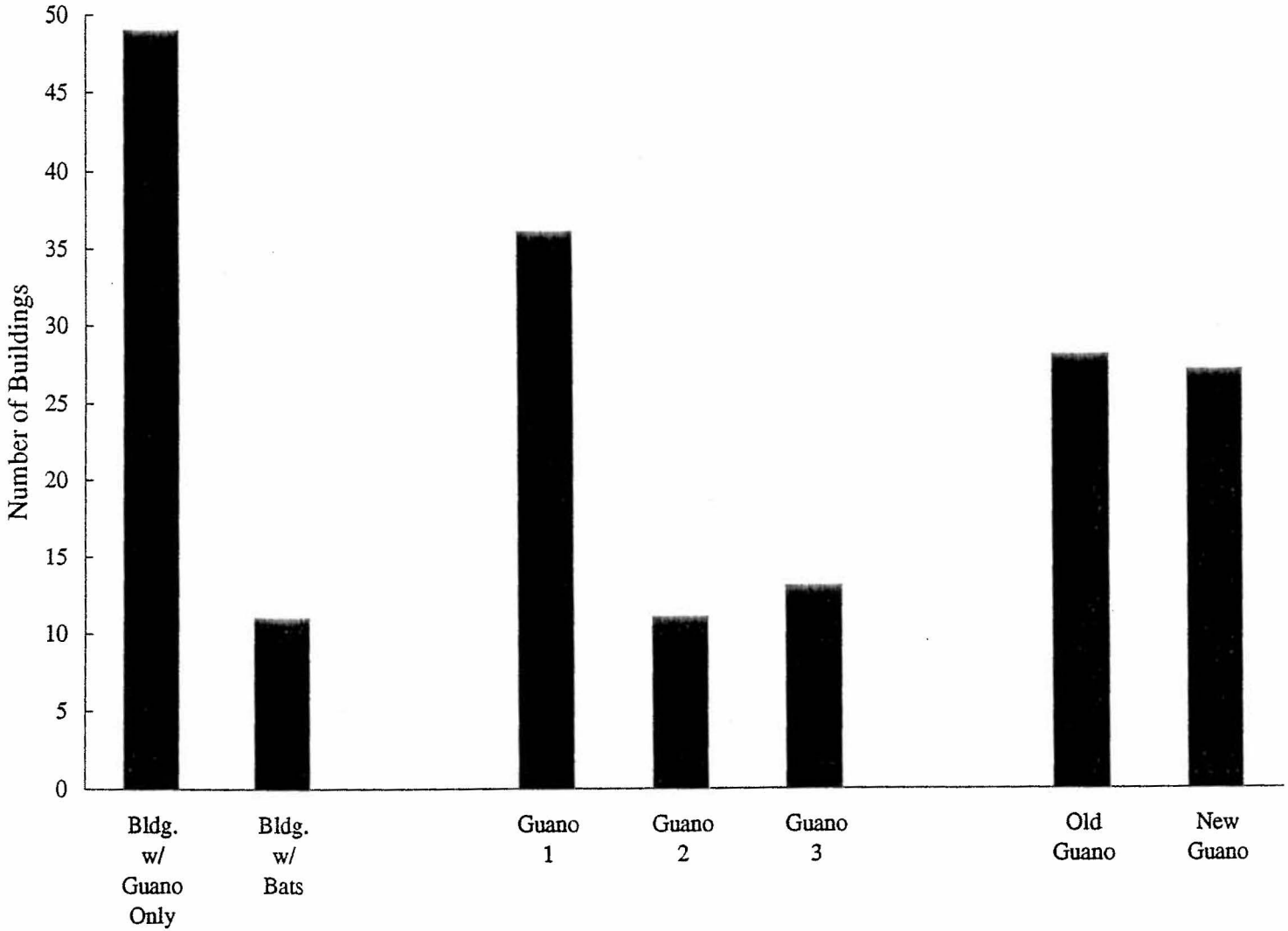


Fig. 2. Half hourly temperatures in the attic of the cafeteria in Giant Forest Village and inside the basal hollow of a giant sequoia tree (NE6, G2) from August 20-October 8, 1995.

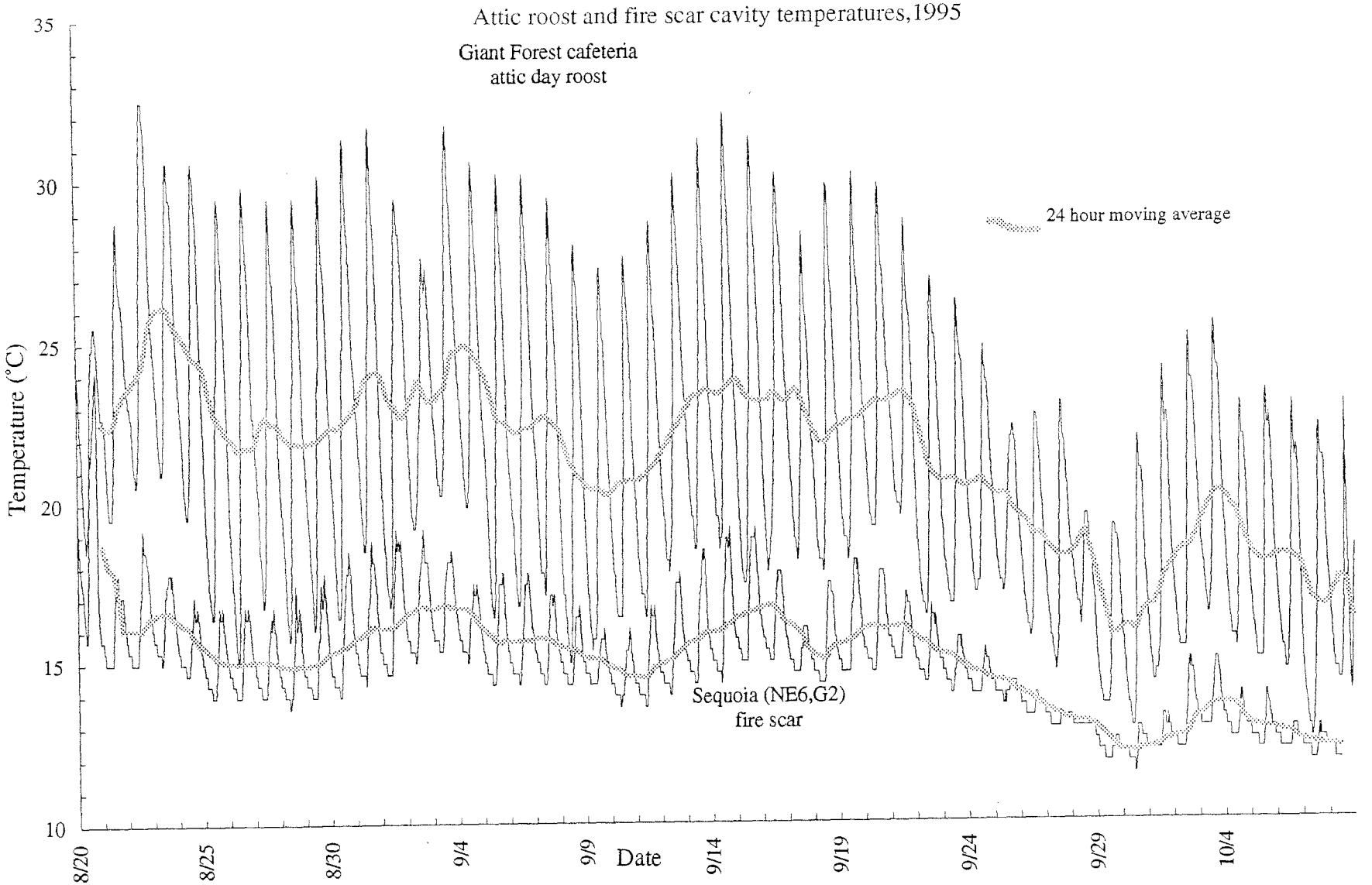

Attic roost and fire scar cavity temperatures,1995
Giant Forest cafeteria
attic day roost
24 hour moving average
Sequoia (NE6,G2)
fire scar
Temperature (°C)
35
30
25
20
15
10
8/20
8/25
8/30
9/4
9/9
9/14
9/19
9/24
9/29
10/4
Date

Fig. 3. Accumulation of guano and culled prey (mg/day) in 24 debris traps installed inside basal hollows of gaint sequoia trees.

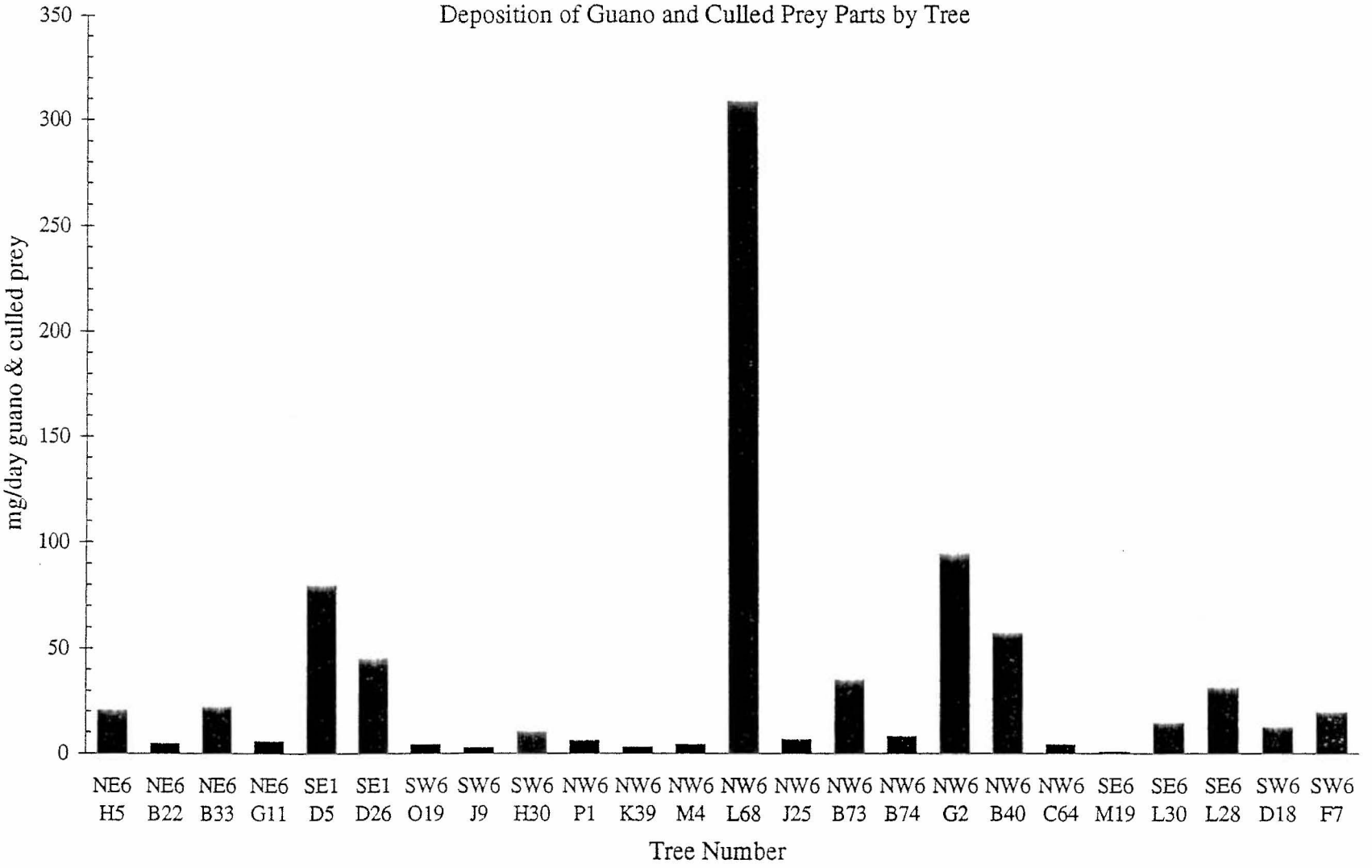
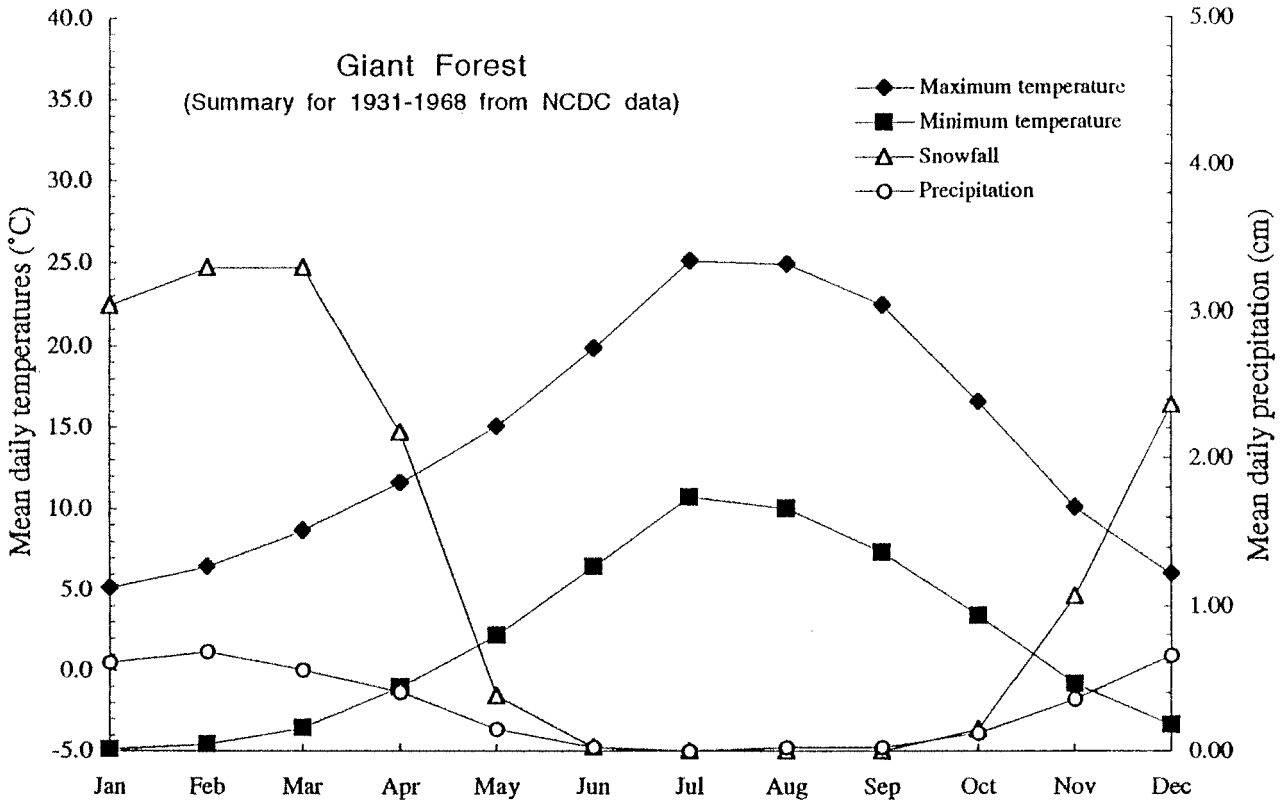

Deposition of Guano and Culled Prey Parts by Tree
mg/day guano & culled prey
350
300
250
200
150
100
50
0
NE6 H5
NE6 B22
NE6 B33
NE6 G11
SE1 D5
SE1 D26
SW6 O19
SW6 J9
SW6 H30
NW6 P1
NW6 K39
NW6 M4
NW6 L68
NW6 J25
NW6 B73
NW6 B74
NW6 G2
NW6 B40
NW6 C64
SE6 M19
SE6 L30
SE6 L28
SW6 D18
SW6 F7
Tree Number

Fig. 4. Average monthly maximium and minimum temperatures, snowfall and preciptitation at Giant Forest and Ash Mountain, 1948-1994.


Giant Forest
(Summary for 1931-1968 from NCDC data)
Maximum temperature
Minimum temperature
Snowfall
Precipitation
Mean daily temperatures (°C)
Mean daily precipitation (cm)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
5.00
4.00
3.00
2.00
1.00
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

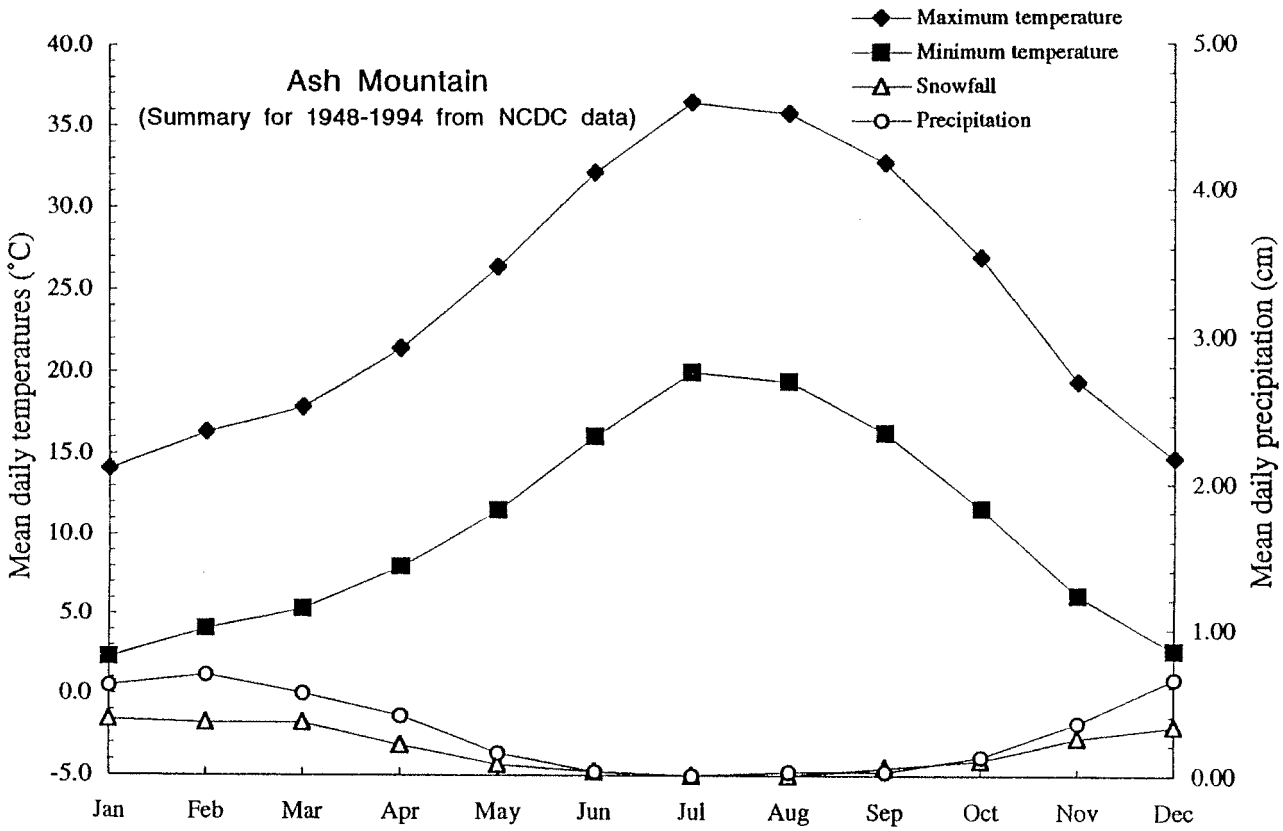

Ash Mountain
(Summary for 1948-1994 from NCDC data)
Maximum temperature
Minimum temperature
Snowfall
Precipitation
Mean daily temperatures (°C)
Mean daily precipitation (cm)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
5.00
4.00
3.00
2.00
1.00
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Fig 5. Lactating female spotted bat, *Euderma maculatum*, captured in a mist net at Sunset Rock, September 13, 1995.